DRAFT

POLICY SUMMARY OF PSSU

Goal/Target Setting

What are the implications of current science for setting of targets/benchmarks for any indicator? Are we measuring the right elements of the ecosystem to accurately gauge progress toward Puget Sound recovery and inform strategic decisions toward achieving this outcome?

Targets are a tricky issue for science to tackle because they refer to desired states of the Puget Sound ecosystem, and those desires are best represented by asking the public what they want (within obvious legal or regulatory constraints). In addition, given current and historical data availability, it is challenging for scientists to identify a single point value or range of values to act as a target for any given indicator. Nonetheless, the PSSU reviews 4 broad categories of targets: reference directions, baselines, nonlinearities, and social norms, and emphasizes that even with the limited scientific information presently available, it is still possible to move forward on targets.

It is important to recognize that because of interactions among different ecosystem components, the target selected for one indicator constrains the realm of ecologically or socially possible targets for other indicators. This notion of trade-offs raises the question of which indicators, or PSP goals, should be given the highest priority. By not consciously prioritizing goals, the PSP has de facto concluded that all goals have equal importance. While this may be true, the PSSU argues that this is a decision that should follow from deliberation rather than occur by accident.

We are measuring only a small subset of the indicators needed to gauge accurately progress toward recovery. While convenient from a communications perspective, the 20 dashboard indicators are not nearly comprehensive enough to capture all of the information related to the 6 PSP goals (e.g., benthic marine species, the benthic food web, terrestrial species and terrestrial food webs, (among other ecosystem components) are poorly represented by the dashboard indicators). In addition, they do not distinguish among driver/pressure/threat indicators (e.g., % impervious surface, toxics in fish) and state indicators (e.g., area of eelgrass, herring abundance). Chapter 1a of the PSSU reveals huge data gaps for a variety of species, food webs, and habitats: More funds and intellectual resources need to be focused on digitizing historic data and initiating new monitoring programs. Appropriate sampling designs that provide information across the entire Sound and at sufficient frequencies are a must.

While data and scientific capacity are a constraint in the marine system, this issue is even more extreme in the terrestrial habitats of Puget Sound. More attention on the terrestrial habitats of the Puget Sound is needed.

Are we measuring indicators and interpreting the related data appropriately through the monitoring and assessment program?

Yes, but there are many data gaps. Even for exploited species there is a lack of monitoring programs-- Dungeness crab being the most obvious example in marine systems, but rockfishes, Pacific hake, and flatfishes could easily be added to the list. To gauge progress toward the species and food web goal, it is not sufficient to monitor fisheries landings--we need fishery-independent estimates (based on well designed surveys) of abundances and biomass. For unexploited species, data availability are even more sparse; jellyfish, ratfish, and flatfish are common and important members of the Puget Sound food web but little is known about their status and trends.

Again, the situation appears even more dire in non-marine habitats.

Ecosystem recovery monitoring systems in place do not include indicators of human wellbeing or the human dimension. Very little emphasis or resources have been devoted to this area of inquiry. The PSSU reveals that the PSP needs to put more effort into identifying the right set of robust indicators of quality of life and human dimensions of ecosystem recovery. Chapter 1b really points to the conclusion that the PSP needs to create conceptual models and related result chains that clearly link with the natural system models and results chains that have already been developed. Unless this is done, the PSP will have no clear decision path to the choice of effective recovery strategies. The latter will allow the PSP to better understand human system dynamics and behavioral change as related to management and or recovery practices.

While existing PSP staff may be fully subscribed as they fulfill their mandate of monitoring, it is important for PSP to encourage and facilitate collaboration with academics and other scholars and practitioners. This could/would increase the insight gained from existing monitoring strategies. More explicit connections need to be drawn between scenarios of future ecosystem drivers (climate change, economics, socio-political environment) and targets, to ensure that targets are realistic, and under what conditions they are achievable.

Are there any ecosystem indicator thresholds that would suggest changes to ecosystem states that need to be avoided or managed to recover Puget Sound? If so, what are they and how should they be reflected in the Action Agenda?

Probably, but this question is also a very tricky one to answer scientifically. The premise of thresholds is that there exist nonlinear relationships between some pressure applied to the ecosystem and the response of an indicator. Often these thresholds are difficult to pinpoint before they have been exceeded. There are some model-based approaches available, particularly with respect to food web properties such as diversity, production rates, and mean trophic level, that could be used to identify thresholds. Where physical events determine thresholds, available data may inform the identification of thresholds. For example, hypoxic and anoxic events in Hood Canal suggest a threshold amount of flushing is required to prevent low oxygen events. Estuarine plants and animals are adapted for lower salinities than wholly marine species; thus, a threshold amount of freshwater flushing and runoff is required for them to persist. Importantly, we lack sufficient understanding of the links between drivers or pressures and ecosystem status, thus, a theme throughout several of the PSSU sections (notably sections 1a and 3) is the need to link threats to ecosystem function.

What are effective ways to engage scientists, policymakers, and the public in setting goals/targets?

An effective way to engage people in setting targets is to communicate to them directly. In the case of scientists, the more clear the PSP can be about the management endpoints it cares about and the management actions under consideration, the better able scientists will be to outline possible outcomes under alternative scenarios. For instance, PSSU section 1a notes that some of the indicator criteria they used were difficult to operationalize because PSP documents are often vague with regards to specific management objectives. In terms of engaging the public, there are a variety of social science techniques available to elicit public opinions about the environment. Most of these techniques rely on structured surveys to understand people's preferences in situations where they are forced to recognize ecological, social, and legal constraints or trade-offs.

Threats

Has the current or future importance of specific threats, as reflected by the Action Agenda priorities, changed? If so, how?

Multiple human activities affect the marine environment in complex ways, yet current management tends to consider each activity separately. For example, effects of climate change are expected to change patterns of precipitation and runoff, increase average temperatures, and contribute to sea level rise and other effects. These impacts will combine with effects from development, shoreline modification, pollutant runoff, and invasions of non-native species to create complicated problems that can not be addressed in a piece-meal fashion. For the PSP to successfully implement an EBM approach that addresses cumulative impacts will require: 1) an evaluation of how human activities interact, 2) a determination of the cumulative impacts of these activities on ecosystem functioning over time and space, and 3) creation of incentive, regulatory, or management mechanisms to account for or allow adjustments in interactions across different activities.

Ultimately, understanding, managing for, and mitigating cumulative impacts requires an understanding of the underlying social drivers of impacts. Based on census, economic, and other data sets, it is feasible to develop assessments of demographic and economic trends at various scales and to evaluate their interactions with patterns of resource use to generate scenarios of possible futures. However, it is more difficult to capture the more fundamental drivers of human activity, including the socio-political, cultural, and religious dimensions that shape human motivations, patterns and levels of demand, and the distribution of power and wealth. Indeed, there is only one (not peer reviewed) comprehensive environmental valuation study and limited social surveys in Puget Sound. There is a need for life satisfaction and "willingness to pay " studies (observed behavior or stated preference) that allow us to better understand what it is that people want and need and how this is affected by ecosystem recovery actions (both positive and negative). The PSP needs to better understand how social and cultural capital enables stewardship among region residents. Social capital can be measured as behavioral (quantitative), attitudinal (quantitative) or attitude/beliefs (qualitative). Current Section 2b work needs to be

completed to identify the best approach to understanding the regions social capital and how best to harness it in further recovery efforts. More expert social scientists need to be added to PSP's Science Panel (or PSP staff?) to move us forward in designing appropriate strategies.

Has the urgency (e.g., immediate need for restorative actions or increased funding) to address specific threats changed, even if their relative importance has not? If so, how?

A key finding in Chapter 3, was that the authors did not encounter a peer-reviewed analysis of the relative magnitude of threats for Puget Sound proper. Thus, it is difficult to scientifically answer a question about changes in the relative importance of specific threats.

In the absence of sound science, "urgency" may be a function of current events (e.g., recent hypoxia and fish kills in Hood Canal), may be influenced by agency agendas or needs (e.g. Ecology's need to establish monitoring requirements for municipal stormwater permits, industrial permits, and boatyard permits, and/or public perception (e.g. statements by policy makers that stormwater runoff is the major problem for Puget Sound).

Clearly there is an urgent need is to conduct a comprehensive analysis of threats followed by a careful prioritization of threats both for the marine and non-marine portions of the ecosystem as well as the natural and human well-being components of the system.

Are there new threats that need to be accounted for in Action Agenda priorities and implementation efforts?

Climate change is an overarching threat emphasized in Chapter 3. While mentioned throughout the Action Agenda, climate change has not been emphasized by the PSP in its ongoing work. Perhaps this is because climate change is viewed as a global issue without a local solution. Nonetheless, it will be increasingly important to consider climate variability and climate change when implementing actions so that there is a better chance that some climate effects can be mitigated and increases the probability that ecological systems can better adapt to climate forcing. For example, our present understanding of the threats to Puget Sound may be sufficient for identifying areas at risk of eutrophication on the basis of stratification intensity and surface water residence time.

Ocean acidification is often lumped with climate change impacts. However, acidification is a growing concern with potentially substantial impacts on shellfish aquaculture and natural communities, and is only recently being considered.

Are the Action Agenda priorities and implementation efforts collectively effectively focusing on the most important threats?

As noted above, a process for quantitatively ranking threats is not yet available. Although the PSSU recommends tools and approaches for characterizing risks and evaluating ecosystem level responses to threats, it is critical that such efforts be supported. Currently, the relative importance of threats is being defined by ad hoc groups of experts using the open standards

approach. Ultimately, this approach is severely limited and potentially biased by the scientists who are willing to engage in the process.

Can we better estimate the level of effort necessary to effectively address a threat?

Not really.

Strategies

Are any current strategies to abate specific threats clearly inadequate, i.e., will not improve ecosystem outcomes?

The PSSU did not adequately address this question.

Can current strategies be improved or made more efficient (e.g., address multiple threats)?

As was true in other sections of the PSSU, the gap between human and natural ecosystem components is striking and may affect the efficiency and efficacy of management strategies. A clear connection between conceptual models and results chains completed for the natural system to those for the human dimension is currently lacking. Until this connection is made, the PSP will be unable to effectively generate scientifically credible indicators of human well being, delineate targets of human behavior which need to modified, or generate actions that will lead to the behavior modifications that are needed to ensure ecosystem recovery.

The Action Agenda probably does not adequately address future potential recovery scenarios that incorporate human dimensions (key socioeconomic drivers) and ecological uncertainties. Consequently, while the strategies currently in the Action Agenda may be relevant and well meaning, there is still a great need to assure that we are doing those things that result in the greatest benefits or return on investment. Currently the choice and implementation of actions is neither based on priorities or a transparent and well delineated decision process. The PSP does not have a suite of decision tools that can be used to prioritize actions spatially and or temporally and across issues or threats. Chapter 3 emphasizes the need for ecosystem models and decision tools that include costs and benefits (monetized when possible) of an action, public support or sociopolitical acceptability, technical effectiveness, risk, and recognized trade-offs. No one tool is likely to achieve this aim, and there are a number of ongoing efforts in the region to build such tools. The PSP should review the emerging toolbox of models and support those that will inform decisions the PSP must make.

Further investment in research related to ecosystem services should yield information that is central to strategy evaluation. There are a variety of ways to classify services, the most common being the categories proposed by the Millennium Assessment: provisioning services (e.g., seafood), regulating services (e.g., of water quality, storm protection), cultural services (e.g., recreational, spiritual, and other nonmaterial benefits), and supporting services that underlie all others (e.g., nutrient cycling, photosynthesis). Understanding what the key services are in a particular area provides a clearer picture of what sectors need to be included in an effective

strategy and where existing strategies may be overlooking important interactions among sectors. Second, it is helpful to assess the spatial distribution of services, including information about the quantities or levels of each service and some measure of their value. Service mapping reveals where there are likely to be important synergies and conflicts among sectors and is critical when setting spatial boundaries for management and policies. Additionally, assessing the value of services requires information about the spatial relationship between service supply and demand and thus service maps are an important starting point for identifying which locations are likely to have the highest service value.

Assessing the market and non-market value of services and developing mechanisms for evaluating trade-offs among different management options provides a direct tie between ecosystem services and current decision making. Knowing the range of factors affecting service production and delivery reveals how management decisions or other drivers will affect the delivery of services. Because, ecosystem services represent a dynamic connection between social and ecological systems, it is important to understand how humans respond to changes in the price of commodities that depend on ecosystem services or changes in access (e.g., beach closures), and how such responses in turn affect the ecosystem.

Which strategies for recovery may be more feasible given the social science understanding of public acceptance of different recovery strategies?

The outreach and education strategies (e.g., EcoNet), while potentially effective among groups already familiar with and in favor of ecosystem recovery, are not reaching a large percentage of Puget Sound citizens. In this region we have a wide diversity of perspectives with regards to the marine ecosystem or Puget Sound Watershed. In some cases, individuals could care less what happens to Puget Sound if they feel there is little or no implication for their quality of life. More emphasis needs to be placed on implementation of outreach and education strategies that reach a wider audience and have clear implications (for health, well being and economic impact) for ecosystem recovery to all residents. Help people to help Puget Sound recover. Create incentives to achieve the behavioral change that is necessary. Thus, any recovery program or project implemented by the PSP should have a strong, targeted outreach and education component included in its design.

Information Needs

In what areas does the lack of natural scientific information most constrain the understanding of risks and uncertainties driving affecting policy decisions?

In some cases there has been a lack of attention to specific aspects of the ecosystem.

- There is a dearth of information on the biophysical condition of Puget Sound terrestrial environments, with the exception of stream water flow metrics. This affects our understanding of management targets, risk and greatly increases uncertainty about what strategies will be effective.

- More monitoring of natural variability in both pelagic and benthic food webs is needed.

- Comprehensive sampling of invasive species and determination of the impacts of non-indigenous species on PSP goals is necessary

- Ocean acidification is an emerging threat that requires rigorous monitoring and evaluation.

In other cases there are information needs because there is a mismatch between the scales of data collection and management.

- Species, Habitat, Water quality, and Water quantity have been collected over relatively short time periods or have not been collected consistently. Since many of these attributes (e.g., species, flows, concentrations) have quite high interannual variability, this precludes detection of significant long-term trends.
- Changing or inconsistent sampling protocols hampers interpretation of trends data. For example, PCBs reported from some studies in the PSSU document have been analyzed using a range of methodologies, including analysis of mixtures (Aroclor) and use of congener-based methods. Similarly, fish surveys change protocol resulting in data that is extremely difficult to interpret. Additionally, while fecal coliform levels in Puget Sound are well documented, disparate data sources make understanding broad spatial and temporal trends challenging, thereby obscuring potentially important patterns. Careful evaluation of all methods, including those for biological covariates, must be made when comparing these data across studies, across time periods and when applying threshold criteria.

We lack an understanding of the relationship between drivers and pressures and ecosystem state.

- For example, the relative importance of the factors driving fluctuations in the distribution and abundance of eelgrass in Puget Sound is not well understood. Changes in key abiotic factors such as water clarity and nutrient levels may be important, yet analyses linking such abiotic data to eelgrass abundances have not been conducted. Consequently, the causes for declines in eelgrass cover are not known, nor are the ecological consequences of such declines for the taxa that utilize eelgrass habitat such as birds, invertebrates and fishes.

As noted elsewhere, there is a critical need to understand the cumulative impacts of multiple stressors.

Numerous sections of the PSSU highlight the importance of improving models of biophysical actions. Ongoing research is working to develop detailed biophysical models of Puget Sound that will be useful for gauging the contributions of human activities to changes in trophic status of Puget Sound and for identifying the most effective policy interventions to prevent worsening conditions. However, many of these efforts are currently underfunded or being developed without interaction with the PSP. Specifically Chapter 3 makes the following recommendations regarding models:

1. Expand the mass balance model (Ecopath with Ecosim) to the entire Salish Sea and eventually replace it with the Atlantis model. This effort will allow managers to identify effective indicators at the scale of the Salish Sea and the use of the Atlantis model will allow better coupling between functional groups and abiotic features like temperature, circulation, nutrients and dissolved oxygen; spatial dynamics that allow simulation of multiple basins of Puget Sound; species-habitat interactions; and more realistic representation of life history features such as age structure, migrations, and prey switching. Atlantis also enables simulation of monitoring and assessment programs designed to evaluate the effectiveness of management policies
2. Continue to link modeling efforts as demonstrated by the linking of cycling and circulation models to investigate causes of low oxygen events. Such links allow researchers to expand the scope and scale of inference and take advantage of existing efforts.
3. When causes of ecosystem change are not well understood, as is the case with low oxygen levels in Hood Canal, models can be used to understand the causes of these types of events.

Chapter 3

A thorough understanding of hypoxia and the response of species and food webs to low dissolved oxygen (DO) is needed. Because of high interannual variability, it is not possible to discern whether the intensity or spatial extent of hypoxia has been growing over recent years. Moreover, the long-term effects of regular exposure to seasonal hypoxia on communities and food webs has not yet been published.

Work on ecological interactions has tended to focus on a limited set of processes (mostly related to habitat or predator-prey interactions). This leads to a skewed, and undoubtedly incorrect view of how the ecosystem operates (and thus what indicators we measures, what their targets are, and what the risk to those indicators is). Future work should consider extrinsic drivers of recruitment (e.g. climate variability), competition, parasites, and disease. In addition, consideration of a wider suite of harmful algal blooms (HABs)s and the conditions that lead to HABs is necessary.

In general we need a more complete understanding of the dynamic linkages between terrestrial and marine systems.

In what areas does the lack of social scientific information most constrain the understanding of risks and uncertainties driving policy decisions?

As stated previously, there is a general lack or social, economic, or institutional studies focused on the Puget Sound region. This lack of information is a serious constraint in our understanding of the risks and uncertainties. Indeed, this lack of social science information could be THE key uncertainty in forecasting the short- to medium term success of particular policy options.

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The PSSU is organized around these chapters 1) ecosystem indicators, 2) current conditions, 3) threats, and 4) strategies. Could this be reorganized to better inform decisions guiding recovery? If so, how?

This is a fine way to organize the PSSU. There is no need to alter this framework, except possibly to separate the target information in Section 1a from the indicator work. NOAA has adopted this framework as a way to present their Integrated Ecosystem Assessment for the California Current, and this framework meshes well with the Open Standards approach. Thus, the current framework not only does a good job of framing the issues, it integrates well with the larger ecosystem management community.

Which chapters and elements within chapters should the science community focus on for the next PSSU, as a means of improving our strategic approach to Puget Sound recovery?

There is a need to complete the indicators evaluation in Section 1a.
Additionally, Section 1a did not evaluate pressure/threat indicators, and these should be evaluated.

Is there information or data not encompassed in the Science Update that is important to Action Agenda policy considerations and needs to be integrated in the near term? How much effort and what process are appropriate to achieve this integration?